Silver recovery from end-of-life c-Si PV cells using HNO_3 and MSA-H_2O_2 leaching

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Introduction

- Rapid PV expansion is driving up end-of-life (EoL) module waste, increasing the need for efficient recycling and resource recovery [1] [2].
- Crystalline silicon (c-Si) modules contain valuable silver, but conventional nitric acid (HNO_3) leaching generates hazardous NOx emissions, motivating greener alternatives such as methanesulfonic acid-hydrogen peroxide (MSA-H_2O_2) [3].
- This project compares HNO_3 and MSA-H_2O_2 for silver recovery from EoL c-Si cells, including the effect of thermal pretreatment.



Material received

Aim & Objectives

Investigate silver recovery from EoL c-Si PV cells and evaluate MSA-H_2O_2 as a more sustainable alternative to HNO_3

HNO_3 Nitric acid

VS

MSA-H_2O_2 Methanesulfonic acid-hydrogen peroxide

Objectives

- Compare silver leaching from furnace-treated and untreated material.
- Determine suitable conditions, kinetics and activation energy for HNO_3 and MSA-H_2O_2 leaching.
- Assess selectivity through co-dissolved base metals.

Pretreatment workflow



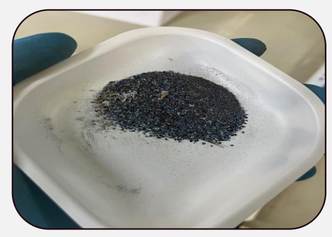
Toluene soak
Swells bottom EVA encapsulant layer



Backsheet removal
Mechanical removal of the backsheet



Furnace treatment
520 °C decomposes residual polymers



Fine powder
Suitable for hydrometallurgical processing

Module types

3 Distinct c-Si PV module configurations identified

Each behaved differently during pretreatment



Configuration 1



Configuration 2



Configuration 3

Planned experiments

Table 1: Experimental factors and corresponding levels to be used in leaching experiments.

Level	Temperature (°C)	HNO_3 (M)	MSA (M)	H_2O_2 (M)
Low (−1)	25	1	1	0.3
Middle (0)	50	3	3	0.9
High (+1)	75	5	5	1.5

- **Design:** full factorial, 3 levels per factor
- **HNO_3:** temperature × HNO_3 concentration
- **MSA-H_2O_2:** temperature × MSA × H_2O_2 concentration
- **Fixed**: 100 g/L solids loading, 6 hours leaching time

Analysis & modelling

- **Kinetics**: shrinking core model
- **Temperature**: Arrhenius analysis
- **Variables**: ANOVA and response surface methodology for significance and interaction

References

[1] Tao, J. & Yu, S. 2015. Review on feasible recycling pathways and technologies of solarphotovoltaic modules. Solar Energy Materials & Solar Cells, 141:108–124. DOI: https://doi.org/10.1016/j.solmat.2015.05.005

[2] Weckend, S., Wade, A. & Heath, G. 2016. END-OF-LIFE MANAGEMENT Solar Photovoltaic Panels: International Renewable Energy Agency.

[3] Yang, E.-H., Lee, J.-K., Lee, J.-S., Ahn, Y.-S., Kang, G.-H. & Cho, C.-H. 2017. Environmentally friendly recovery of Ag from end-of-life c-Si solar cell using organic acid and its electrochemical purification. Hydrometallurgy, 167:129–133. DOI: https://doi.org/10.1016/j.hydromet.2016.11.005